WCMC Biodiversity Series No 3

Priorities for Conserving Global Species Richness and Endemism

WORLD CONSERVATION
MONITORING CENTRE

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by the

World Conservation Monitoring Centre

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J.O. Caldecott, M.D. Jenkins, T. Johnson and B. Groombridge

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Priorities for Conserving Global Species Richness and Endemism

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This document

This report was originally prepared by the World Conservation Monitoring Centre (WCMC) in June 1994 under contract to the Overseas Development Administration (ODA), UK. The task assigned to WCMC, with particular reference to the *Convention on Biological Diversity*, was: to discuss priorities for the conservation of global biological diversity, to assess what policies would be required, to suggest where the Convention and its financial mechanism should focus their efforts, and with what results. The document is now made available in the present format by kind permission of the ODA (this version differs from the original in a few minor improvements to the text and the addition of a map).

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Summary

A primary aim of the Convention on Biological Diversity is to encourage and enable all countries to conserve biodiversity and to use its components sustainably in support of national development.

Biodiversity means the diversity of living organisms, including diversity of species and ecosystems. Two very important attributes of biodiversity are species richness (the number of species in an area) and endemism (the number of species in that area which occur nowhere else). More information is available at a global level on these attributes than on other aspects of biodiversity. Because they reflect the complexity, uniqueness and intactness of natural ecosystems, they indicate overall concentrations of biodiversity in a useful way.

Current knowledge of country level species richness and endemism for mammals, birds and higher plants is generally adequate for some decision-making purposes. However, information on other taxonomic groups is far less complete, and knowledge of richness and endemism for such groups is poor.

It is also known that biodiversity is not evenly distributed in the world. Some areas are much richer in species and endemics than others. Broad geographical differences between groups of countries also exist. The tropical countries lying between the Indian and the Pacific Oceans, and the countries of northern South America and Central America are particularly rich in species and endemics.

A number of important actions which countries can take to implement the Convention and maintain their biodiversity can be readily identified. However, there is a need for the Conference of the Parties to adopt specific priorities for immediate action, which should reflect, *inter alia*, the global distribution of biodiversity and the threats to it.

Prevailing scientific opinion is that the next few decades will be a period of maximum danger for the diversity of species and ecosystems around the world. It is not possible to know the precise number of species which are becoming extinct or are likely to do so, but some projections suggest that at least 10 and possibly 40 per cent of the world's present species are likely to be extinct within 50 years. By acting now, the world community can help to minimise the eventual scale of species losses. This can best be achieved by managing communities of organisms in the wild, using on-site (*in situ*) measures.

Major immediate priorities should be:-

a) to strengthen the management of ecosystems and habitats containing a disproportionately large share of the world's terrestrial and marine biodiversity;

b) to help developing countries to complete national biodiversity strategies and action plans, to initiate procedures to monitor their own biodiversity, and to take steps to establish and maintain adequate national systems of conservation areas;

c) to support actions at the global level, providing benefit to all countries in managing their own biodiversity.

The choice of sites for priority action should be made using a variety of criteria. Generally, resources will best be spent in safeguarding ecosystems and habitats that are both viable and important for global biodiversity, and which are threatened by factors that can be controlled cost-effectively. It is proposed that on the basis of these criteria, and using the best available information on the global

distribution of biodiversity, a list (or series of lists) of high priority terrestrial and marine ecosystems and habitats should be prepared.

Three further criteria for selecting sites for investment are representativeness, complementarity and insurance. Representativeness will ensure that adequate samples of distinct ecosystems are selected for management, and is uniquely relevant to making global choices. Complementarity is concerned with ensuring that samples of all distinct ecosystems within a country are included within its national system of protected areas. Insurance recognises the need for some duplication in the coverage of ecosystems to offset the risks of planning failure, project failure and other factors such as climate change.

Article 6 of the Convention requires each country to prepare a biodiversity strategy and action plan. Each Party should determine its own institutional and other arrangements for preparing national biodiversity strategies and action plans in accordance with Article 6 of the Convention. The process of consultation in each country should, however, be as broad as possible, embracing all relevant government and non-governmental institutions and organisations.

Each Party should also determine the terms of reference for its own planning exercises in accordance with Article 6. The scope of enquiry should, however, include national arrangements for:-

- Basic maintenance of all aspects of biodiversity;
- Co-ordinated and systematic planning activities;
- Development of an adequate infrastructure;
- Broadening ownership of and involvement in management of biodiversity.

Each Party should also identify and monitor its biodiversity, in accordance with Article 7. Analysis of currently available data indicates that global biodiversity is concentrated in some 65 countries of which 60 may be regarded as less developed. The latter should be given special consideration in the allocation of resources to assist them in improving their capacity to manage biodiversity and in particular to enable them to comply substantively with Articles 6, 7 and 8 of the Convention.

The financing mechanism of the Convention should also support actions at the global level, including: firstly, promoting coordination among the agencies which implement existing international agreements; secondly, promoting sharing of experience from conservation projects between nations and agencies; and thirdly, managing global information to provide effective services for the exchange and repatriation of scientific data, and for monitoring the status of biodiversity and providing early warning of threats to its components.

The framework for the global early warning system should be a comprehensive and regularly updated global inventory of those ecosystems and habitats, species and communities, and genomes and genes described in Annex I of the Convention. Such an inventory and early warning system will provide a vital part of the information needed to identify future global priorities for action.

Introduction

Biological diversity, or biodiversity, refers to the variety of distinct ecosystems or habitats, the number and variety of species within them, and the range of genetic diversity within the populations of each of those species. It therefore means the richness and variety of living things in the world as a whole or in any location within it. Two attributes of biodiversity have attracted particular attention from the international conservation community: species richness (the number of species in an area), and endemism (the number of species in that area which occur nowhere else). More information is available at a global level on these attributes than on any other, and, because they reflect the complexity, uniqueness and intactness of natural ecosystems, they are believed to indicate overall patterns of biodiversity in a useful way. This report focuses on species richness and endemism for these reasons.

The Convention on Biological Diversity has among its objectives "the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources" (Article 1). Components of biodiversity are described in Annex I of the Convention, and include ecosystems, species and genetic lineages. There is broad agreement that conservation depends partly on treating certain of these components only in ways that do not adversely impact upon them, for example, maintenance in protected areas where management responds mainly to the long-term needs of biodiversity. Conservation also depends partly on a willingness to use sustainably other components of biodiversity, in ways which respond mainly to the long-term needs of people. The sharing of benefits is also seen as a way to ensure that both these kinds of use are rewarded, so that they can become permanent.

The Convention's primary aim is to encourage and enable all countries to conserve biodiversity and to use its components sustainably in support of national development. It is in the nature of biodiversity management that many policies and actions must converge and support one another if success is to be achieved. The logical basis for policy and action is integral to the Convention itself, and a list of actions directly based on the provisions of Articles 6-14 and 17-18 was given by UNEP (1993), with a further commentary by IUCN (1993a) and de Klemm & Shine (1993).

Among the many possible responses, there are ten important actions that countries can take to implement the Convention (WRI, 1994):

- *In response to Article 6:* develop national plans, strategies, and/or policies to improve the capacity to conserve biodiversity and to use its components sustainably.
- *In response to Article 7:* identify important components of biodiversity (ie. ecosystems, species, lineages, etc.), conduct biodiversity inventories and surveys, identify activities that adversely affect biodiversity, and develop a system for organizing and maintaining this information so that it may be acted upon.
- *In response to Article 8:* (a) establish or strengthen networks of national protected areas in order to protect species, habitats, representative ecosystems and genetic variability within species; (b) control, eradicate or prevent the introduction of alien species that threaten ecosystems, habitats or indigenous species; and (c) develop or maintain necessary legislation, institutional capacities and other provisions for the protection of threatened species and populations.
- *In response to Articles 8, 10 and 11:* manage and use biological resources sustainably outside protected areas, including degraded ecosystems, and adopt economic and social incentives to that end.
- *In response to Article 9:* establish and/or strengthen facilities for the off-site (*ex-situ*) conservation of biodiversity that support and complement on-site (*in-situ*) conservation efforts.

- *In response to Article 14:* improve legislation and institutional capacity to assess and manage the impacts of planned or existing projects, programmes or policies on the environment in general and on biodiversity in particular, while also encouraging public participation.
- *In response to Article 15:* consider options for developing national and/or state or provincial regulations to govern access to and exploitation of genetic resources.
- *In response to Article 20:* increase resources to support effective biodiversity conservation in those developing countries which undertake the above actions.

The kinds of action envisioned by the Convention are thus fairly clear, but listing them does not much help to establish immediate priorities for action. This is important, since Articles 20 and 21 of the Convention state that financial resources shall be made available through a financing mechanism, by which Parties will be helped to fulfil their obligations under the Convention. There is a need for the Conference of the Parties to adopt specific priorities for immediate action, and those priorities should, *inter alia*, respond to the global distribution of biodiversity and threats to it.

Prevailing scientific opinion is that the next few decades will be a period of maximum danger for species and ecosystems around the world. It has been predicted that at least 10 and possibly 40 per cent of the world's present species are likely to be extinct within 50 years (WRI, IUCN & UNEP, 1992), although there is significant uncertainty in the calculations on which such estimates are based (WCMC, 1992). By acting now, the world community can help to minimize the eventual scale of species losses, by taking action which affects the factors causing the losses.

Genetic erosion, the decline and extinction of species and the degradation of ecosystems will reduce the ability of biodiversity to support national development and to sustain future human well-being at a global level. The well-being of current and future generations of people in all countries would therefore best be served if these processes were kept to a minimum in the next few decades. Information already exists to allow the location of many of the world's most important components of biodiversity to be reliably identified. The priorities of the financing mechanism should take account of this information, by including measures to reduce rates of habitat degradation and species extinction in and around such locations. An additional aim should be to ensure that representative and viable samples of all distinct ecosystems are protected and managed for conservation purposes. Such immediate priorities will also provide a basis for more long-term strategic actions and benefit-sharing called for under the Convention.

The Convention envisions that assistance in biodiversity management will be provided in many forms, including financial assistance but also through the protection of the intellectual property rights of nations and communities, and the transfer of relevant technology including biotechnology. Protection of property rights to biodiversity is necessary for sustainable biodiversity management, since it helps to ensure that countries themselves derive benefit from development based on biodiversity. Technology transfer will make it possible for all countries to obtain such benefits, and biotechnology is considered to embrace all knowledge, skills and techniques needed to manage the components of biodiversity sustainably, whether in the laboratory, in captivity or in the wild.

This report focuses on the intent of the Convention to conserve species and their natural habitats described in Annex 1 to the Convention, and this can best be done by managing communities of organisms in the wild, using on-site (*in situ*) measures.

Particular stress is laid on the role of planning, priority-setting and conservation action at the national level in accordance with Articles 6, 7 and 8 of the Convention. Another factor, however, is that some actions are immediately justifiable on the basis of current knowledge, and these should be undertaken as soon as possible to counter decline in biodiversity. Details are given below, but in summary it is

proposed that the financing mechanism should be given the necessary mandate to respond as soon as possible:

- in support of conservation action to safeguard viable samples of terrestrial habitats known to be rich in species and/or high in endemism, including but not limited to areas which are legally protected but which are threatened by factors which can be controlled in a cost-effective manner;
- in support of conservation action to safeguard marine and coastal areas known to be rich in species and/or high in endemism, or to support exceptional levels of biological productivity of benefit to people;
- in support of conservation action to safeguard other sites of special merit for biodiversity, including areas of lowland tropical forest, temperate grassland, cave systems, islands, isolated mountains, seamounts, lakes, rivers and wetlands;
- in support of countries known to be rich in species and endemism, thus helping them to comply substantively with Articles 6, 7 and 8 of the Convention; and
- in support of actions which can best be undertaken at a global level, including coordinating activity under existing international agreements and programmes which affect biodiversity, monitoring threats to global biodiversity, collecting, analysing and disseminating information on biodiversity, and promoting the exchange of skills in biodiversity management.

This would allow the following aims to be achieved at the same time and with maximum efficiency, transparency, and opportunity to define precise and achievable targets:

- to strengthen the management of many sites containing a disproportionately large share of the world's terrestrial and marine biodiversity;
- to help the countries with most biodiversity to complete national biodiversity strategies and action plans, to initiate procedures to monitor their own biodiversity, and to take steps to establish and maintain adequate national systems of conservation areas;
- to support actions at the global level, providing benefit to all countries in managing their own biodiversity.

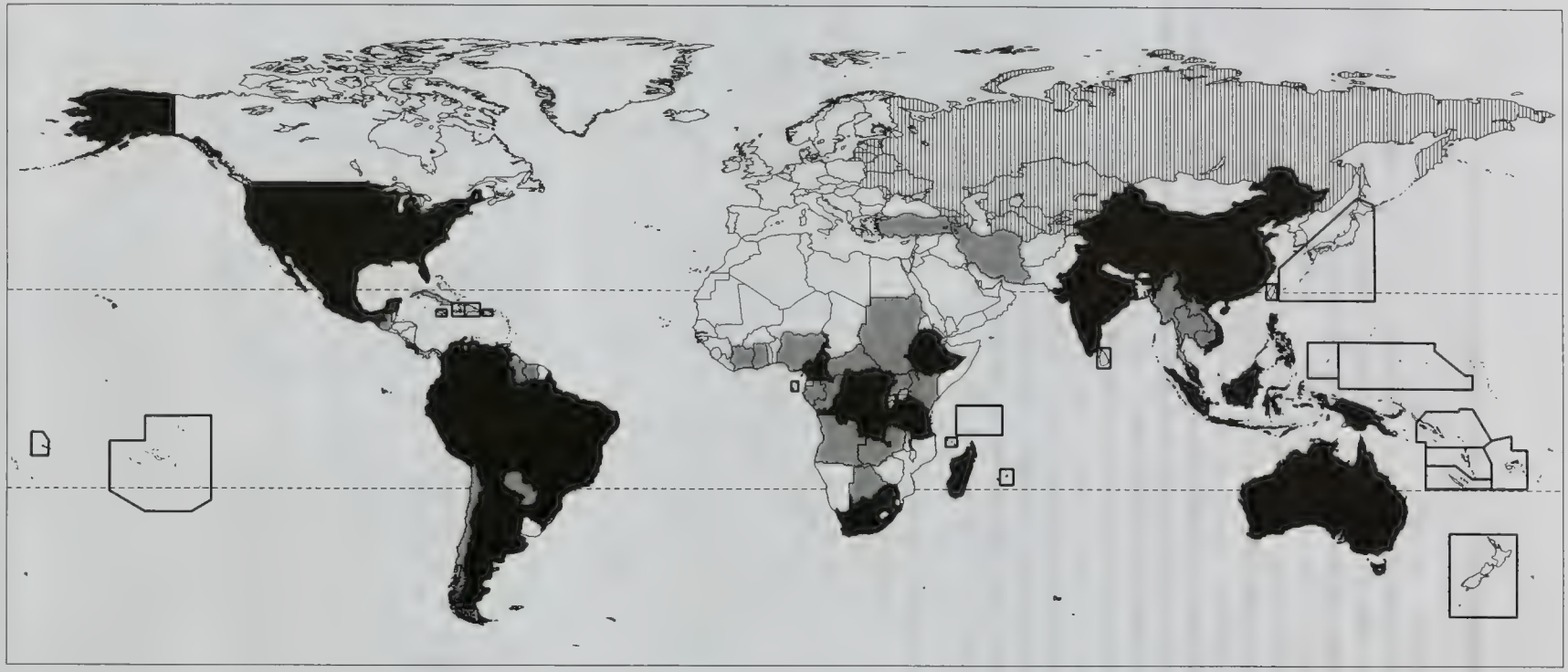

Figure 1. Map to show countries with higher levels of biodiversity

Countries with higher levels of biodiversity are here put into three groups to indicate in general terms the contribution made to global biodiversity. Group 1 countries have the highest levels of overall biodiversity. Group 2 have the next highest levels. Group 3 includes island countries particularly rich in endemic species. See page 17.

Key: black, Group 1; grey, Group 2; line boxes, Group 3.

Note: the former USSR (vertical hatching) would have appeared in Group 1; complete data not yet available for all newly independent states.

Source: data and calculation of national biodiversity index in WCMC (in prep), also outlined in WCMC, 1994, *Biodiversity Data Sourcebook*, World Conservation Press, Cambridge.

Knowledge of Biodiversity

Biodiversity is valued and has been studied largely because it is used, and could be used better, to sustain and increase human well-being. It is used indirectly as an attribute of natural ecosystems such as forests, grasslands and seas, which protect watersheds, stabilize climate, and provide food. It also directly provides materials that are used and traded by people, in the form of timber, meat, fish, fruits, nuts, spices, vegetables, perfumes, seed oils, fodder, anti-microbial agents, other pharmaceuticals, pesticides, food colourants, flavours and food preservatives, dyes, adhesives, resins, gums, waxes and latexes (Reid & Miller, 1989). Many medicines came originally from wild plants and animals, and over 3,000 plant species have been used for food by people at one time or another (Myers, 1983; Spellerberg & Hardes, 1992). A major part of human nutrition is now provided by just 30 species of crop plants, however, and a supply of new genetic material for these is needed if they are to resist disease and continue to improve their productivity (McNeely, 1993a).

Current knowledge of biodiversity can be separated into global, regional, national, ecoregional and site information. At the global level, the following general rules apply (with some exceptions) to terrestrial locations, and analogues of several of the same rules apply to marine ones:

- warmer areas support more species than colder ones;
- wetter areas support more species than drier ones;
- less seasonal areas support more species than very seasonal ones;
- areas with varied topography and climatic conditions support more species than uniform ones;
- larger areas support more species than smaller ones;
- isolated areas support more endemic species than areas which are contiguous or close to other similar areas; and
- the longer an area has been isolated, the higher the number of endemic species likely to be found there.

Broad differences between groups of countries have also been detected. Exceptional richness and endemism among both terrestrial and marine species, for example, is found in tropical countries lying between the Indian and the Pacific Oceans, and in the countries of northern South America and Central America. These differences have their origin in geological and evolutionary history, but they are not fully understood.

Current knowledge of species richness among mammals, birds and higher plants is generally adequate for many purposes in most countries, but is far less complete for other groups. Knowledge of global species richness overall is poor, with fewer than two million species known, against an estimated total number of species of at least 10 million and possibly as many as 100 million. This uncertainty is partly a consequence of the fact that many countries have limited expertise in, and facilities for, the study of systematics and taxonomy, and poor access to modern literature. They therefore tend to rely excessively on collections held in foreign institutions to which they have imperfect access.

These constraints also mean that there is limited knowledge of comparative species richness among higher taxa at known locations, since few protected areas have adequate inventories and ecoregional assessments are scattered and patchy in coverage. As a result, there are few cases where selected taxa have been demonstrated to be useful indicators of general levels of biodiversity, although it seems likely that, for example, bird species with small ranges will be able to fulfil this role to some extent (see Section: *Exceptional Areas for Biodiversity*).

There is no single objective way to assign global significance to all forms of biodiversity, and the process of setting priorities will vary between countries according to local perceptions and local

objectives for development. *For most countries and for the world as a whole, however, there is sufficient information on species richness and endemism to allow realistic decisions to be made on where at the country level these attributes are likely to be most pronounced, and where investment in safeguarding them would be most effective.*

Although there is enough information to start this process, there is also a clear need for better documentation of the natural world and of the species it contains. The role of a national biodiversity inventory in each country will be defined through the process of preparing its own national biodiversity strategy and action plan, as required by Article 6. In this process, it will be important for each country to consider its own need for biodiversity data to address Article 7 and Annex I. By answering such questions as: "what are the data for?", and "who will use them when they are collected?", each country will obtain a clearer understanding of its own need for knowledge about biodiversity, and what role that information can have in helping biodiversity to be managed sustainably in accordance with national objectives (Janzen *et al.*, 1993).

National inventories would also generate data which, if made accessible to global information networks, would clarify many issues relevant to conservation problems at a global level. Maintaining information on global biodiversity, and collating, freely circulating and providing it on request, will comprise an important global service which should be supported under the Convention. All countries will benefit from access to information with which to support their own efforts in biodiversity management.

Threats to Biodiversity

Priorities for conserving biodiversity should derive from knowledge of the distribution of biodiversity in relation to the location and nature of threats to it. Threats to the components of biodiversity involve the themes of habitat change, introduced species, pollution, unsustainable harvesting of wild species, and direct competition for living space and other resources between people and wild species. These threats often result from the following kinds of underlying problem, all of which tend to be accentuated by excessive human population densities:

- *planning failure,* in which plans are made to use living systems in ways which they cannot sustain because of their inherent fragility;
- *market failure,* in which the people who benefit from damaging living systems do not also bear the full cost of that damage;
- *excessive wealth among some individuals,* making them so remote from the rest of society that they become reckless of damage to the living systems which sustain society;
- *excessive poverty among many individuals,* making them unable to avoid abusing living systems in order to live while depriving them of the means to use such systems better; and
- *open-access exploitation,* in which social rules governing access to resources within living systems have broken down, allowing them to be exploited competitively by different groups and individuals.

The causes of biodiversity loss are multiple and synergistic (McNeely, 1993b), and single factors, acting alone, seldom have an irreversible impact on biodiversity. Much current deforestation, for example, is ascribed by the World Bank (1994) to a combination of factors acting together, including improved access by logging roads, leading to colonization and uncontrolled clearance for farms in areas with insecure land tenure and poorly-defined rights to use resources. This highlights the need for national policies which encourage the cross-sectoral analysis and management (ie. avoidance, mitigation or compensation) of environmental and social impacts, and which encourage just and sustainable solutions to fundamental conflicts of interest among people.

The subjective perceptions of threat by field managers of conservation areas are often the only source of information on those threats. Such reports were given by WCMC (1992) for worldwide centres of plant diversity (see Section: *Exceptional Areas for Biodiversity*), and in order of decreasing frequency they were as follows:

- harvesting of timber as logs, charcoal, poles, etc.;
- expanding farms and plantations;
- grazing and ranching of livestock;
- tourism and other visitor pressures;
- population growth, immigration and colonization;
- mineral exploitation, including oil and gas, mines and quarries;
- development of transport, communications, military facilities, dams and other infrastructure;
- harvesting of vegetation for medicinal and ornamental plants, canes, etc.;
- fire;
- introduced species of plants and animals;
- urban and industrial spread; and
- other threats from refugees, erosion, agricultural, industrial and urban pollution, etc.

Estimates of the number of species becoming extinct each day at present range from several to several hundred (Raven, 1988; Reid, 1992). Extinction rates have not been measured directly, being inferred instead from knowledge of species richness and endemism in various ecosystems, known rates of

fragmentation and degradation of those ecosystems, and assumptions about the likelihood of species with very specific habitat needs surviving in altered environments. It is also significant that some populations can persist for a few generations within disturbed habitats, but will eventually die out if regeneration of the habitat does not occur. This means that species can become committed to extinction well before the last members of that species actually die, and that overall biodiversity will continue to decline in the future as these 'living dead' meet their fates (Janzen, 1986).

It is not possible to know the precise number of species which are becoming extinct or are likely to do so, but all available evidence points to rates that are far higher than background extinction rates over geological time. Action to conserve biodiversity is therefore considered to be needed, and is expected often to involve controlling threats through site-related projects. Interventions, however, should both generate incentives to conserve and strengthen the capacity of countries to influence the factors which cause threats to national biodiversity. These themes are linked because a country's capacity to conserve will be improved by the experience of solving problems, but this learning process requires sufficient flexibility of policy to allow learning to occur.

Because of the variety of threats and their interactive and variable nature, it can be difficult to determine levels of threat to any particular component of biodiversity at any given time. The Species Survival Commission of IUCN has been revising its widely used categories of threat to taxa; the penultimate draft of the new system is given in Mace and Stuart (1994). *As an operational definition of endangered species, it is proposed that the Convention adopts that used in the revised IUCN Red List categories as and when these are finalized and adopted by IUCN. The term endangered species as understood by the Convention should cover the IUCN categories 'Critically Endangered' and 'Endangered'.*

Defining an endangered habitat is even more problematic than defining an endangered species or other taxon. The definition of habitat under the Convention is "the place or type of site where an organism or population naturally occurs". This indicates that each type of organism (usually a species) or even each naturally occurring population of an organism has its own habitat determined by its specific ecological requirements. By this definition, the status of a habitat (ie. whether it is endangered or not) will be defined by its capacity to continue supporting the particular organism under discussion. Any given site will usually support more than one type of organism. Its characteristics may change (through human interference or otherwise) so that it can no longer support some of these organisms, but can still continue to support others. The status of the habitat will therefore be different according to which organism is being considered. For this reason it seems more satisfactory to assess the status of particular sites according to the status of organisms inhabiting them, which can be classified according to the system noted in the paragraph above.

As well as these difficulties in assessing and classifying degree of threat, there is also debate about the best allocation of resources in response to levels of threat where these can be measured. This turns on whether resources should be allocated, as a priority, to areas which are severely threatened, or whether such investments should be made by preference in areas where threats are slight to moderate, and the chance of long-term success is therefore high.

Resources will usually best be spent in safeguarding areas which are both viable and important for biodiversity, but which are threatened by factors which can be controlled and where investment will be likely to succeed and be cost effective. This approach would tend to discourage major investment in areas which have been allowed to become critically threatened and are likely to be destroyed in the immediate future despite the investment. It would also tend to discourage major investment in areas which are remote and under little threat, although in such cases the role of monitoring and early warning of incipient threats is likely to be very important. Since this would not necessarily be expensive, such actions would be likely to be highly cost-effective.

Exceptional Areas for Biodiversity

Options for selecting priority areas

Many criteria can be used to identify areas which are of high priority for conservation (Johnson, 1993). Reid *et al.* (1993) list 22 such criteria, and an earlier but influential example is given by McNeely *et al.* (1990), who suggest using a combination of:

- *distinctiveness*, which emphasizes protecting habitats which are rare in themselves, or which belong to biogeographic units which are not represented in protected areas, or which contain endemic species or species which are taxonomically unique;
- *threat*, which emphasizes protecting threatened areas and rare or endangered species; and
- *utility*, which emphasizes protecting species and ecosystems which if lost will adversely affect human well-being.

These and other selection criteria have weaknesses, including the need for adequate information with which to perceive threats, and for judgement in deciding what to do about them. Furthermore there is no single overall measure of biodiversity and consequently there is no simple way of setting priorities on the basis of a site's contribution to global biodiversity. The concept of utility or usefulness is also ambiguous, since species or ecosystems with a high perceived use value might be expected to be safeguarded locally, making the need for external assistance less rather than more acute; the real issue here is whether the use value of a component of biodiversity is perceived locally, and whether the people who perceive that value are in a position to manage biodiversity effectively.

The most important identifiable areas for biodiversity are those ecosystems and habitats that contain many species, and those that contain species that occur nowhere else (ie. endemic species), as well as ecosystems and habitats that are taken to be representative samples of major or rare ecosystems, or which contain large numbers of genetic lineages of economic value. This is the rationale for Annex I of the Convention, which identifies important components of biodiversity in the same way.

There are a number of ways in which representative samples of habitats can be chosen for conservation action at a global level. Three of the major criteria for selecting sites for investment should be *representativeness*, *complementarity* and *insurance* or *redundancy*. The first criterion is intended to ensure that adequate samples of distinct ecosystems are selected for management, and is uniquely relevant to making global choices. The criterion of complementarity is concerned with ensuring that samples of all distinct ecosystems within a country are included within its national system of protected areas. The third criterion indicates the need for some duplication in the coverage of such systems, however, to offset the risks of planning failure, project failure and other factors such as climate change.

Using a combination of the above criteria, it is possible to derive lists of high priority terrestrial and marine sites for the conservation of biodiversity. These sites should be given special consideration in the allocation of resources under the Convention. The best available information on the global distribution of biodiversity, is discussed in more detail below.

Endemic bird areas

There has been only one consistent and comprehensive global assessment of animal biodiversity at the level of ecoregions, which are ecologically distinct biogeographical units comprising parts of countries or trans-frontier areas. This was a study of restricted-range bird species, which are those with an historical breeding range of 50,000 square kilometres or less (ICBP, 1992). The study

identified 221 endemic bird areas (EBAs) where such birds are confined, and scored them according to the number of restricted-range bird species per unit area in each EBA, their taxonomic uniqueness, and the level of endemism in each EBA among other animals and plants, yielding an index of overall biological importance. This was combined with an assessment of threat and current protection, to give an index of priority for conservation.

The study showed that about 26% of all bird species are limited to less than 5% of the world's land area. Conservation action on just 2% of total land area could greatly enhance the survival prospects of one in five of the world's birds, including a high proportion of those at risk. This is a very important finding, since the scale of the areas needing to be protected is well within the capacity of most countries to allocate to conservation purposes. It is also important to note that ICBP (1992) found in many cases a positive correlation between concentrations of restricted-range birds, and the location of other endemics, particularly vertebrates. Similar conclusions were reached by other studies (eg. MacKinnon *et al.*, 1994), implying that conservation action targeted on EBAs will have collateral benefit for many other taxa. The fact that EBAs show high levels of endemism in relatively small areas of habitat, means that although these sites are vulnerable because they are small, they are also excellent targets for focused, sustained and cost-effective conservation effort.

Centres of plant diversity

The only worldwide study of plant biodiversity at an ecoregional level, comparable to that on EBAs, has involved defining about 250 centres of plant diversity (CPDs) (IUCN & WWF, 1988; WWF & IUCN, in press). These are defined as areas which are known to be rich in species and endemics, and to fulfil several other or related criteria, including the presence of an important gene pool of plants of value to people, a diverse concentration of habitat types, a high proportion of species adapted to local soil conditions, and some degree of threat to the ecological integrity of the area.

The locations which fulfil these criteria tend to be isolated geographical units such as islands and mountains, or mountain ranges, or else are distinctive floristic provinces. They are located in all continents (except Antarctica) and all oceans, and range in size from under one hundred hectares to over one hundred million hectares. Many areas have been identified where CPDs overlap with endemic bird areas and/or with existing legally-protected areas, which is helpful in drawing attention to sites of exceptional biodiversity. Plant species richness and endemism are expected, because of coevolutionary processes, to correlate well with the same features among invertebrates and especially insects. Since restricted-range birds appear to correlate well with endemic vertebrates in general, EBAs and CPDs may well have complementary roles in identifying important sites for biodiversity.

Systems reviews

There have been several efforts in the recent past to identify priorities among the world's existing network of conservation areas. These include reviews of protected area systems in the Afrotropical, Indo-Malayan and Oceanian realms (IUCN & UNEP, 1986a, 1986b, 1986c), which continue to be reviewed and updated (eg. Braatz *et al.*, 1992; SPREP, 1992; J. MacKinnon, 1994) and are currently being expanded to include Latin America and the Caribbean (Olson & Dinerstein, 1994). In addition, numerous national initiatives have already been undertaken, including national environmental action plans (NEAPs), tropical forestry action plans (TFAPs), conservation strategies and biodiversity country studies.

This work should be used to focus attention on sites which are consistently identified as being of special importance for biodiversity. Thus, there are already lists for some countries of sites which must be safeguarded if key components of their national biodiversity resources are to be retained. An example is provided by 80-90 sites in Indonesia, which were identified as vital by the country's

National Conservation Plan (FAO, 1981-1982), and in later studies by the Ministry of Transmigration (RePPProt, 1990), the National Development Planning Agency (BAPPENAS, 1991), the Ministry of Forestry (MoF/FAO, 1991), and the Ministry State for Environment (KLH, 1992). Similarly, many important wetland sites have been identified in regional studies (eg. Scott, 1989), and about 1,000 locations have been listed under the Ramsar Convention as vital wetlands, or else are listed as Biosphere Reserves or natural World Heritage Sites. Locations where national and international priorities coincide in this way are logical candidates for conservation investment.

There is also work underway to develop methods for assessing the conservation potential of ecoregions in the Latin American and Caribbean area (Olson & Dinerstein, 1994), and this is now being expanded to the global level (Saterson *et al.*, 1994). The intention of this work is to build up a layered model of each ecoregion incorporating landscape features, patterns of species richness and endemism, critical habitats, protected areas, management activities, human demography and other social, economic and political factors that collectively influence conservation priorities for the ecoregion. This approach is promising, in that it will build upon the analyses described above while also incorporating much other information.

Coastal and marine areas

Most of the world's people live in coastal zones, which contain many extremely productive habitats. In addition to the direct impact of settlement, exploitation and pollution generated within them, coastal zones are also exposed to environmental impacts created offshore or within the water catchments inland from them. The mixing of nutrient flows from land and sea, which make these zones so dynamic, thus also exposes them to unique dangers (Johannes & Hatcher, 1986; Ray, 1988, 1991). Mangrove swamps, sea-grass beds, salt marshes and coral reefs are all examples of coastal environments which are very important in sustaining human life, but which are in serious decline at a global level. All support biological communities which extend far out to sea, as well as human trade and subsistence patterns which extend far inland.

About 71% of the Earth's surface is covered by sea, but oceanic biodiversity is far less well known than its terrestrial counterpart (Angel, 1991, 1992; Peterson, 1992). The sea contains almost all known animal phyla (basic life-form designs), but nearly half of these do not occur on dry land at all, and concerns about marine biodiversity tend to focus on taxonomic levels higher than that of species. Species richness is also less useful for setting priorities in the sea than on land, partly because so many species occur in the central Indo-Pacific region, from the Philippines to Indonesia and Northern Australia. This feature correlates poorly with marine endemism, and species richness is only considered useful in comparing sites within biogeographical regions, and then only within ecosystem types and not among them (Norse, 1993).

Patterns of occurrence of organisms in the sea are harder to discover and to map than on land, because so many of them have larval planktonic phases during which they disperse widely. Nevertheless, known differences among marine areas allow some priorities to emerge. Areas of high marine endemism tend to be common in temperate and marginally-tropical regions, where temperature gradients with latitude are steep, or where there is shelter from major environmental fluctuations (Norse, 1993). For many groups of algae and invertebrates, examples include:

- the northern (off Senegal) and southern (off Angola) limits of the West African maritime province;
- waters off south-eastern Brazil and nearby parts of Uruguay and Argentina;
- the northern (Sea of Cortéz, México) and southern (off Ecuador and northern Perú) limits of the Panamic maritime province in the eastern Pacific;
- warm-temperate Japan and nearby waters off Korea and China;

- waters off the south-western Cape of South Africa; and
- temperate Australian waters.

Other zones of high endemism include isolated islands or oceanic basins (Gage & Tyler, 1991; Norse, 1993), including:

- the Okhotsk Sea and Kurile Islands in the north-west Pacific;
- the continental coast of northern South America;
- the South Atlantic oceanic islands (especially St Helena, Ascension and Fernando de Noronha);
- the Red Sea;
- the Coral Sea;
- the islands of Polynesia (especially Hawai'i, the Marquesas, Easter Island, the Societies and Tuamotus);
- the Galápagos Islands;
- the Mediterranean Sea;
- the Arctic Ocean-Norwegian Sea; and
- the coastal waters of Antarctica.

Most existing marine protected areas were established to safeguard environments essential to maintaining fisheries productivity. These include spawning and nursery grounds, migration corridors and stopover points, all of which are important both for the species which use them, and for the people who use those species. An additional factor is that areas of upwelling cover less than 1% of the world's oceans but contribute more that 30% of the total recorded catch. These occur mainly off the western coasts of continents, particularly in the tropical and sub-tropical trade-wind belts, and around Antarctica (Norse, 1993). They also occur seasonally, for example in eastern Indonesia and off north-western Australia in August (Muller, 1992). They are important resources for predatory species that require dense concentrations of food fishes. These predatory species include fishes, mammals such as seals and sea lions, birds such as penguins, and people.

A global representative system of marine and coastal areas has been developed, taking into account all current knowledge of marine and coastal species richness, endemism and productivity (Kelleher & Bleakley, 1992). This considered a total of 1,182 existing protected areas and, derived from these and gaps in coverage, a list of 100-150 areas which are considered to be priorities for the conservation of global marine biodiversity. Even in many of these priority areas, and certainly elsewhere in the oceans including other regions of high biodiversity and productivity, the total protection of habitats is not an appropriate response to the need to conserve biodiversity. Instead, the emphasis should be on sustainable use and integrated management of large areas, with particular attention to the exclusion of activities that do indiscriminate damage to large amounts of marine life. Foremost among these would be pollution and the use of fishing techniques which cause serious over-harvesting or wastage.

Open-access exploitation is a special danger in marine situations, the solution to which requires licensing and careful monitoring of fishing activity. At a national level, this implies the need to help countries to enforce their right to control access to marine resources within their territorial waters and exclusive economic zones. At a local level, the same principle would favour helping coastal communities which use near-shore fisheries (whether for fishing or to support tourism) to use them exclusively. A large part of the ocean, however, is non-territorial and is not owned by any nation, which means that the management of open-ocean resources must be addressed through international agreements, including the Antarctic Treaty and the Conventions on the Law of the Sea and on Biological Diversity (de Klemm & Shine, 1993).

National Species Richness and Endemism

Myers (1988) identified twelve biodiversity 'hotspots', which collectively amount to less than 1% of the world's land area, but which contain about 14% of the total number of plant species. Subsequent work on species richness and endemism for a range of different taxa by Mittermeier & Werner (1990), and by McNeely *et al.* (1990) identified several 'megadiversity' countries. This approach has been developed further by WCMC (1992 and in prep.), drawing on increasingly comprehensive documentation of biodiversity for all countries.

Examples of current data at WCMC on species richness and endemism are given in Tables 1-4 (see Annex). The 50 countries with highest estimated totals in each case are listed in decreasing order: plant species (Table 1), mammals and birds (Table 2), endemic mammals and birds (Table 3), and endemic amphibians (Table 4). Inspection of these lists shows that certain countries consistently emerge with high species richness and endemism, and these patterns are generally repeated in less complete datasets for other taxa (WCMC, 1992).

Analyses of all available data by WCMC (in prep), and regional assessments of mammals, birds, amphibians, reptiles, swallowtail butterflies and angiosperms by McNeely *et al.*, (1990), suggest that the 50 countries or territories which possess most species and most endemism can be divided into two groups, as follows, with the countries in each listed in alphabetical order:

- *Group 1* (the 25 most biodiverse countries): Argentina, Australia, Bolivia, Brazil, Cameroon, China, Colombia, Costa Rica, Ecuador, Ethiopia, India, Indonesia, Madagascar, Malaysia, México, Papua New Guinea, Perú, the Philippines, South Africa, Tanzania, the USA, [ex-USSR], Venezuela, Viet Nam and Zaire; and

- *Group 2* (the 25 next most biodiverse countries): Angola, Botswana, Cambodia, Central African Republic, Chile, Congo, Côte d'Ivoire, Cuba, Gabon, Ghana, Guatemala, Guyana, Iran, Kenya, Laos, Myanmar, Nigeria, Panama, Paraguay, Sudan, Suriname, Thailand, Turkey, Uganda and Zambia.

It should be noted, however, that while the difference in species richness and endemism between Group 1 countries and Group 2 countries is marked, the differences between countries within Group 2 are generally very slight, as are the differences between countries in this group and many of those not included among these 50 countries.

A further group of countries are islands or groups of islands which have fewer species in total, but which have a large proportion of native species that occur nowhere else. These include the following 20 endemic-rich countries or territories that do not occur in Group 1 or Group 2 above:

- Comoros, Dominican Republic, Federated States of Micronesia, Fiji, French Polynesia, Haiti, Jamaica, Japan, Mauritius, New Caledonia, New Zealand, Palau, Puerto Rico, São Tomé and Príncipe, Seychelles, Solomon Islands, Sri Lanka, Taiwan, Vanuatu and Western Samoa.

The 60 less developed countries belonging to these three groups should be given special consideration in the allocation of resources to assist them in improving their capacity to manage biodiversity. This means that these countries should be selectively encouraged and enabled to comply substantively with Articles 6, 7 and 8 of the Convention. These Articles require several linked steps which will all contribute strongly to developing national capacity to conserve and manage biodiversity.

Article 6 calls on Parties to develop national plans, strategies, and/or policies to conserve biodiversity and to ensure that their use of biodiversity is sustainable. This Article thus requires each country to prepare a biodiversity strategy and action plan, and therefore to undertake an important process of consultation, planning and consensus-building. Article 7, meanwhile, calls on Parties to identify the important components of their biodiversity, to conduct biodiversity inventories and surveys, to identify activities that adversely affect biodiversity, and to develop a system for organizing and maintaining this information. This Article thus requires the establishment of a biodiversity monitoring capacity in each country.

Article 8 is more complex than Articles 6 and 7, and calls on Parties, *inter alia*, to establish or strengthen networks of national protected areas in order to protect species, habitats, representative ecosystems and genetic variability within species; to control, eradicate or prevent the introduction of alien species that threaten ecosystems, habitats or indigenous species; and to develop or maintain necessary legislation and/or other regulatory provisions for the protection of threatened species and populations. This Article therefore requires each country to create and manage an adequate system of conservation areas. It is of great importance that emphasis is laid on the need for improved management of conservation areas in the implementation of Article 8. Although a number of globally important sites are nominally protected, and many countries have a reasonable system of conservation areas, most such areas receive very little management investment and are in practice only 'paper parks'.

Global Responses to Global Needs

The financing mechanism of the Convention is uniquely able to respond to issues which are best addressed at the global level. There are opportunities, for example:

- to assist in coordinating and maintaining a common focus among the implementing agencies of existing international conventions, agreements and programmes which are relevant to biodiversity management;
- to promote sharing of experience from conservation projects, by supporting analysis, exchange visits and the wide dissemination and discussion of results among agencies and countries; and
- to establish agreed guidelines to help ensure common standards for the inclusiveness, transparency and technical merit of planning processes undertaken in accordance with Article 6, and for screening and selecting proposals derived from them (see Section: *Guidelines and Screening Criteria*).

Information collected by monitoring systems in each country, established under Article 7, could be provided to a global biodiversity monitoring and early-warning system. Such a system was urgently called for by WRI, IUCN & UNEP (1992), as a way to help mobilize effective responses to threats to biodiversity. This call was in response to the speed at which such threats often develop, which can be far greater than the speed at which governments are able to respond to them. Much of the information likely to be of value to a global monitoring system has in the past been collected by non-governmental organizations (NGOs), which should continue to be fully involved in such activities in the future.

The framework for this global early warning system should be a comprehensive and regularly updated global inventory of those ecosystems and habitats, species and communities, and genomes and genes described in Annex I to the Convention. Such an inventory will also be a vital part of the information needed to identify future global priorities for action.

Guidelines and Screening Criteria

Each Party should determine its own institutional and other arrangements for preparing national biodiversity strategies and action plans in accordance with Article 6 of the Convention. The process of consultation in each country should, however, include all relevant ministries, all major universities, museums, research institutions and national environmental NGOs, all relevant trans-sectoral agencies, and all relevant special-interest groups, especially including representatives of aboriginal populations.

Each Party should also determine the terms of reference for its own planning exercises in accordance with Article 6. The scope of enquiry should, however, include national arrangements for:

- Maintaining viable populations of all native plants and animals, well distributed throughout their geographic ranges.
- Maintaining natural genetic variability within and among populations of native species.
- Maintaining representative examples of all ecosystems, communities, habitats and ecological processes.
- Planning and managing conservation areas, including their monitoring and protection.
- Mapping, monitoring and managing information about conservation areas and biodiversity, and conveying such information to the responsible national authorities.
- Managing resources at the landscape level so as to integrate human activities with conserving biodiversity.
- Spatial planning, and managing impacts on the environment in general and on biodiversity in particular.
- Coordinating development across sectors and resolving conflicts between sectors, institutions and social groups.
- Increasing scientific understanding of biodiversity, and applying that understanding to its conservation.
- Promoting public awareness and understanding of biodiversity and its values.
- Enabling and encouraging the private sector to develop and apply innovation to the conservation of biodiversity.
- Reviewing policies and legislation affecting incentives to conserve.
- Allocating adequate resources and using local recovery of costs to support national systems of conservation areas and individual areas.
- Encouraging NGOs to participate in support of government efforts in conservation.
- Using off-site conservation techniques to supplement other conservation activities.
- Considering the implications for training and other aspects of human resource development, within national institutions, and locally around conservation areas.

Large numbers of proposals for biodiversity management projects will need to be processed by the implementing agencies of the financing mechanism of the Convention. Screening these proposals would be made easier if a common structure was adopted, with clear guidelines on the content of each section. The following is a suggested outline drawn from IUCN experience in the light of the Global Environment Facility's first project portfolio (McNeely, 1993b):

- the objectives of the project should be clearly stated;
- its location should be clearly defined and mapped;
- its scientific plan should be thoroughly described and quantified;
- its workplan should provide details of procedures to be used, and a specific timetable;
- its implementation arrangements should list all agencies involved and what they will need to achieve project objectives, including measures for coordination, physical facilities and

infrastructure or plans to improve them, sources of information and ability to manage it, legislative context, monitoring capacity, and personnel capacities or plans to improve them;

- the costs and benefits associated with the project should be described with an indication of their distribution and scale by place, time and social group affected;
- there should be a description of the 'with-project' and 'without-project' scenarios, in a form in which they can be compared;
- the socioeconomic context of the project should be described in enough detail to demonstrate its relevance and likely impact;
- measures for disseminating results and knowledge should be described, indicating who will learn from the project, and how they will find out about it;
- a review of relevant previous work should be annexed.

Site-specific interventions

Most areas of high biodiversity are either already, or will in future be, occupied and used by farmers, fishers, hunters, loggers or other harvesters. These people are likely to collaborate with conservation projects only to the extent that they share the benefits fairly, and are not made to bear too great a share of the costs. Arrangements to achieve this are often best made in the context of resource management and community development plans agreed between local authorities and local people (WRI, IUCN & UNEP, 1992).

Pressures to use living resources in an area unsustainably often reflect economic or social events outside the area. This means that conservation intervention should not be limited, for example, to the enforcement of legal protection for habitats and biodiversity. Instead, projects need to go beyond the borders of protected areas, to improve underlying circumstances elsewhere that may otherwise continue to generate problems. Modern conservation projects therefore tend to have three fundamental components (Brandon & Wells, 1992; Wells & Brandon, 1992):

- conservation activities, to protect flora and fauna within reserve boundaries, usually by prohibiting illegal logging, hunting, fishing and agricultural encroachment;
- agricultural services, to develop alternative sources of income in adjoining areas to relieve the need to exploit the reserve's resources for profit or survival; and
- community development programmes, to ensure that local people are involved in all aspects of the project, and to provide an effective interface between the local population and the government agency implementing it.

Such a project thus aims to achieve a balance between these approaches, reflecting the fact that none of them alone is likely to be sufficient where serious threats to a reserve exist. The following more detailed principles have emerged from a review of international experience in conservation project design (Caldecott, in press):

- *Balance incentives and disincentives*, since providing alternative sources of income will not stop people from over-harvesting resources unless linked to other measures such as enforcement and education.
- *Negotiate formal and monitored agreements*, preferably recognizing traditional and communal ownership and usage rights, whereby project benefits are exchanged for co-operation with conservation aims.
- *Maximize local participation*, by helping local communities express their own development options and priorities in a form to which the project can respond.
- *Employ and train local people* wherever possible, either directly or through local NGOs, who can be involved in long-term community development programs.
- *Recognize gender differences*, use gender analysis of all project interventions, and selectively involve and train women, who often have a disproportionate influence on environmental management and family planning.
- *Localize management authority* for the project to a group in which all local interests are represented, consistent with the need for national oversight, coordination with other agencies, and conflict resolution.
- *Seek to ensure sustainable financing*, through local cost recovery, endowments, or other means to reduce dependency on subsidies from outside the project area.
- *Manage whole ecological units*, rather than trying to manage biodiversity in isolation from its geographical, social, economic and political context.

- *Help projects to be supported by policy*, by designing them in the context of comprehensive biodiversity management strategies.
- *Help to build local capacity* and encourage local participation and flexibility, by starting with and then building upon small pilot activities.

These principles mean that modern conservation projects are inherently complex and slow to achieve dramatic results, and these factors have delayed consensus on the most suitable methods to use in designing and implementing them. A result is that there are very large differences among the budgets of projects designed to solve similar problems in similar environments over similar periods of time. While there will never be one best approach equally applicable everywhere, it is notable that key variables in project budgets include the extent to which the project relies upon:

- the use of internationally-recruited consultants, instead of those recruited within the country being assisted;
- the use of international volunteers or the staff of international NGOs, instead of consultants;
- the use of local NGOs to perform services, instead of local commercial companies or government agencies; and
- participation of local people within the project area as employees or volunteers in project activities.

Sustainable use of biodiversity

Natural ecosystems such as forests can provide a wide range of economic products, and diverse harvesting systems may achieve multiple yields from the same environment. The most durable management systems are those which avoid open-access use of resources, through tenure and usufruct arrangements providing for long-term and exclusive access by individuals or communities. Where such systems are in place, the need for external intervention may be limited to technical advice and monitoring, to ensure sustainable harvests. Prohibiting such harvesting may cause economic loss to the local people and prompt their hostility. Alternatives include traditional use zones within conservation areas, buffer zones adjacent to them, or community lands elsewhere, which may all be available for certain kinds of continued exploitation by people.

People with a long history of intimate contact with natural ecosystems, such as tropical forests, are typically very knowledgeable about the uses of native species. This knowledge, and the species themselves, may be used in new ways to support the improvement of farming systems in and around a conservation area, for the benefit of local communities. Meanwhile, traditional ways of gleaning forest products for human use need not conflict with conservation aims if they are sustainable. To achieve this, the impact must be considered of each form of exploitation on the potential yields of other forms, and on biodiversity and ecosystem structure in general (IUCN, 1993b, 1994). Project designs should provide for research and management planning to balance the demands of each kind of production, while also putting in place measures needed for monitoring and enforcement.

Social and economic benefits from sustainable use of biodiversity can provide powerful incentives to conserve it, provided that two conditions are fulfilled (IUCN, 1993b). Firstly, the people most likely to have a direct impact on the biodiversity concerned should receive what they perceive as a fair share of the benefits from the use. Secondly, there should be a clear connection between the benefits obtained from using the resources and conservation of them. This will often involve:

- respecting and promoting traditions of local communities that are compatible with conservation of biodiversity;
- providing economic, institutional, biological and other technical assistance on request;
- developing community-level education programmes on the uniqueness of local biodiversity;

- cooperating with rural communities to develop sustainable use projects that demonstrate the value of maintaining local biodiversity; and
- assisting in the development of markets, and promoting access to those markets on favourable terms, for the products of sustainable management of biodiversity.

The role of off-site (*ex-situ*) action

Article 9 of the Convention emphasizes that conservation of species and genetic lineages outside their natural habitats can complement efforts to conserve them in the wild. Investment in off-site measures should, however, take into account the different implications of working with germplasm, plants, invertebrates and vertebrate animals. The cost implications for botanic gardens seeking to hold germplasm collections, for example, were highlighted by WWF & IUCN (1989), and Keystone (1991) calculated costs for off-site conservation of plant genetic resources. The latter assumed a capital cost of US$ 75 per sample, and US$ 50 per sample per year for storage and documentation.

Although quite feasible, the high cost and limited direct conservation role of storing germplasm should discourage investment in this technology except in special cases, for example where lineages are of direct value to agriculture. In such cases, however, other sources of support are likely to be available which may be more appropriate than the financing mechanism of the Convention. Such funds as are available specifically for conserving biodiversity would usually be better spent on managing it in the wild, and on the captive propagation of selected, endangered species where this can be achieved at reasonable cost.

Priorities for conserving wild plant species within botanic gardens include the following (WWF & IUCN, 1989):

- rare and endangered species;
- species or relatives of species which are economically important as sources of medicinal and aromatic materials, foods and drinks, forage and pasture, spices, timber, fuelwood, fruits, fibres, oils, waxes and tannins, or have other uses such as ornamentation;
- species needed for restoring or rehabilitating ecosystems;
- keystone species whose loss would cause other extinctions; and
- taxonomically isolated species with a high degree of uniqueness and scientific interest.

Where a botanical garden is associated with an isolated and endangered ecosystem, its main role should be to save local plant species which are expected to become extinct in the wild. The same principle applies where botanical gardens in one country are involved in captive propagation of endangered species from another, as for example between the Philippines and Hawai'i (Kristiansen *et al.*, 1993). This approach implies the need for field inventories to establish which species in an area are at risk and should be propagated in captivity.

Species of conservation concern in such an area, however, may include all those with small population sizes, which in even a small tropical site may include several thousand species of plants and invertebrates. This implies that off-site work should be carefully targetted, and may also need to include local species of the fauna as well as the flora. A balanced approach adapted to local circumstances would be best, involving also the promotion of community education, ecological research and training, collaboration with other botanic gardens and conservation groups, and ecotourism as a source of revenues to support conservation activities.

Propagating animals in captivity poses a number of problems. Few proven techniques yet exist for working with invertebrates, (Samways, 1994), although some butterflies are an exception (Collins & Morris, 1985). The captive maintenance of vertebrates, and especially large birds and mammals, is

problematical for other reasons. Animals from such collections can only rarely be reintroduced to the wild (Caldecott & Kavanagh, 1988), and maintaining them is very expensive compared to other conservation investments (Balmford *et al.*, submitted a & b). Education is probably the single most important function of modern zoos, but a badly maintained zoo will teach the wrong messages, while still diverting money, public attention and political leadership away from real conservation issues.

Some zoos, however, are effective in educating the public and decision-makers about conservation issues. Zoos can also collaborate to maintain vertebrate species in viable breeding populations, which can be used to restock habitat areas where those species have been lost for reasons that no longer apply. Zoos can also generate funds in support of field conservation work, especially where this helps the species and ecosystems on display at the zoo. Finally, zoos can support captive research which may help some conservation projects. In considering the captive maintenance of animals, an important guide should be the likely maintenance cost of each species relative to the feasibility of reintroducing it to the wild, and to its attractiveness to visitors. Reptiles, amphibians, invertebrates and plants are likely to be more feasible candidates for off-site biodiversity management than are large mammals and birds.

Conclusions

This paper has reviewed the state of current knowledge of global biodiversity, with particular attention to patterns of species richness and endemism. It has also considered the nature of threats to the various components of biodiversity, and some of the main options for controlling those threats and thereby conserving biodiversity. A conclusion is that the financing mechanism of the Convention should seek to balance three complementary priorities. This would mean, firstly, helping countries to safeguard particular areas where outstanding concentrations of species richness and endemism occur. Secondly, it would also mean helping those countries with abundant overall species richness and endemism to strengthen their capacity to conserve. Finally, it would mean helping to provide global services of value to all countries in their efforts to conserve biodiversity. Such immediate priorities will also provide a basis for the more long-term strategic actions and benefit sharing called for under the Convention.

The first approach would affect these and additional countries, by responding to the need to secure representative and viable samples of environments which are known to be rich in endemic and other species. Many such areas have been identified by national and international studies, including locations within endemic bird areas and centres of plant diversity, selected marine and coastal areas, and a variety of other sites of special value for biodiversity.

The second approach would involve giving priority to certain developing countries in allocating resources to help them improve their capacity to conserve biodiversity. The aim would be to help them comply with Articles 6, 7 and 8 of the Convention as soon as possible. The section *National Species Richness and Endemism* above showed that these countries fall into three groups, according to known species richness and endemism: Group 1, with the highest levels of overall biodiversity; Group 2, with the next highest levels; and Group 3, island nations which are particularly rich in endemic species and which merit special attention for this reason.

In choosing priorities for investment, the financing mechanism should normally favour intervention in areas which are viable and important for biodiversity, but which are threatened by factors which can realistically be controlled, and where the investment will be cost effective and likely to succeed. This category of sites will include many existing legally-protected areas which are in need of additional management, and also other important sites which have not yet been legally protected, but which should be so protected before they are degraded.

Other areas, where critical levels of threat exist, or where no threat exists, should usually be considered a lower priority for investment. The financing mechanism should have sufficient flexibility, however, to select investments in response to the needs of highly endangered ecosystems, where these are extremely valuable and there is some special reason to hope that success may be achieved. It should also be possible to invest in monitoring important areas which are not threatened, in order to obtain early warning of changing circumstances.

The third approach proposed here recognizes that the financing mechanism of the Convention is particularly well suited to support some actions at the global level. Such actions would include: firstly, promoting coordination among the agencies which implement existing international agreements; secondly, promoting sharing of experience from conservation projects between nations and agencies; and thirdly, managing global information to provide effective services for the exchange and repatriation of scientific data, and for monitoring the status of biodiversity and providing early warning of threats to its components.

The implementing agencies of the financing mechanism will need selection criteria to allow these priorities to be put into effect, and the following are suggested:

- *representativeness*, to ensure that adequate samples of distinct ecosystems and ecological transitions between them are preserved in the country receiving assistance;
- *complementarity*, to ensure that all distinct ecosystems are included within the national system of conservation areas of the country receiving assistance;
- *insurance*, to ensure that duplicate samples of ecosystems are protected in order to offset the risk of planning failure, project failure and other factors such as climate change;
- *responsibility*, to ensure that actions of the country receiving assistance are supportive of the biodiversity of other countries;
- *cost effectiveness*, to ensure that defined conservation objectives are achieved at least cost;
- *absorptive capacity*, to ensure that governments, institutions and local social systems are able to manage new resources and new responsibilities;
- *context*, to ensure that new investments are consistent with other biodiversity management projects and existing policies in the country receiving assistance;
- *impact*, to ensure that investments which are intended to result in conservation action are carried through from the planning stage to action; and
- *sustainability*, to ensure that investments may become self-financing or financed in such a way as to avoid long-term dependence on external finance.

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Annex

Table 1. Estimated number of plant species in the 50 most plant-rich countries (data missing for Cambodia, Laos and Viet Nam, which would otherwise be expected to be included).

Brazil	55,000
Colombia	50,000
China	30,000
Mexico	25,000
South Africa	23,000
Indonesia	22,500
[ex-USSR]	22,000
Venezuela	20,000
United States	19,000
Ecuador	18,250
Peru	17,000
Bolivia	16,500
Australia	15,500
India	15,000
Malaysia	15,000
Thailand	12,000
Zaire	11,000
Costa Rica	11,000
Papua New Guinea	10,000
Tanzania	10,000
Madagascar	9,000
Panama	9,000
Argentina	9,000
Turkey	8,500
Cameroon	8,000
Philippines	8,000
Guatemala	8,000
Paraguay	7,500
Myanmar	7,000
Nicaragua	7,000
Nepal	6,500
Gabon	6,500
Ethiopia	6,500
Iran	6,500
Kenya	6,000
Guyana	6,000
Cuba	5,996
Mozambique	5,500
Italy	5,463
Bhutan	5,446
[ex-Yugoslavia]	5,250
Chile	5,100
Angola	5,000
French Guiana	5,000
Honduras	5,000
Uganda	5,000
Dominican Republic	5,000
Bangladesh	5,000
Pakistan	4,917
Spain	4,916

Annex

Table 2. Estimated number of mammal and bird species in the 50 most species-rich countries by this measure (bird data are not completely consistent as for some countries some non-resident species have been included).

Mammals		Birds	
Indonesia	515	Colombia	1721
Mexico	439	Peru	1705
Zaire	415	Brazil	1573
China	394	Indonesia	1519
Brazil	394	Ecuador	1435
Colombia	359	Venezuela	1308
United States	346	Bolivia	1257
Peru	344	China	1100
India	317	Zaire	1086
Uganda	315	Kenya	1067
Kenya	309	Tanzania	1016
Tanzania	306	Uganda	989
Myanmar	300	India	969
Cameroon	297	Mexico	961
Venezuela	288	Sudan	938
Australia	282	Panama	922
Bolivia	280	Angola	872
[ex-USSR]	276	Myanmar	867
Angola	276	Cameroon	848
Nigeria	274	Costa Rica	848
Viet Nam	273	Ethiopia	836
Ecuador	271	Nigeria	831
Sudan	267	South Africa	774
Malaysia	264	Zambia	732
Argentina	258	Ghana	721
Ethiopia	255	Côte d'Ivoire	683
Thailand	251	Rwanda	669
South Africa	247	Central African Rep.	668
Papua New Guinea	242	Mozambique	666
Côte d'Ivoire	230	United States	650
Zambia	229	Paraguay	650
Ghana	222	Mali	647
Panama	218	Namibia	640
Central African Rep.	209	Somalia	639
Costa Rica	205	Viet Nam	638
Congo	200	Zimbabwe	635
Togo	196	Burundi	633
Zimbabwe	196	Malawi	630
Malawi	195	Benin	630
Liberia	193	Togo	630
Guyana	193	Nepal	629
Guinea	190	Senegal	625
Gabon	190	Gabon	617
Benin	188	Thailand	616
Suriname	187	Sierra Leone	614
Equatorial Guinea	184	Liberia	590
Mozambique	179	Papua New Guinea	578
Honduras	173	Australia	571
Laos	173	Botswana	569
Somalia	171	Guinea	529

Table 3. Estimated number of endemic mammal and bird species in the 50 most endemic-rich countries by this measure.

Endemic mammals		Endemic birds	
Australia	210	Australia	351
Indonesia	165	Indonesia	258
Mexico	136	Brazil	191
United States	93	Philippines	172
Philippines	90	Peru	106
Brazil	68	Madagascar	97
Madagascar	67	Mexico	88
China	62	New Zealand	74
[ex-USSR]	55	Colombia	73
Papua New Guinea	49	Solomon Islands	72
Argentina	47	United States	69
Peru	46	India	69
India	38	China	63
Japan	29	Papua New Guinea	54
South Africa	27	Venezuela	45
Ethiopia	26	Ecuador	37
Zaire	25	Ethiopia	26
Colombia	22	French Polynesia	25
Ecuador	21	Fiji	25
Solomon Islands	18	Jamaica	25
Cuba	15	São Tomé and Príncipe	24
Malaysia	14	Zaire	23
Taiwan	13	Cuba	22
Tanzania	12	Argentina	21
Sri Lanka	12	Sri Lanka	20
Panama	11	New Caledonia	20
Venezuela	11	Japan	20
Chile	11	Micronesia, Fed. States	18
Kenya	10	Chile	15
Cameroon	10	Bolivia	15
Myanmar	8	Taiwan	15
Somalia	8	[ex-USSR]	13
Costa Rica	8	Tanzania	13
Sudan	7	Angola	12
Bolivia	7	Viet Nam	12
Mongolia	6	Somalia	11
Morocco	5	Puerto Rico	11
Thailand	5	Cameroon	11
Viet Nam	5	Mauritius	10
Libya	4	Palau	10
Iran	4	Vanuatu	10
Canada	4	Seychelles	9
Egypt	4	Comoros	9
Guatemala	4	Yemen	8
Spain	4	Western Samoa	8
Uganda	4	Cook Islands	7
Angola	4	Kenya	7
Gabon	3	South Africa	7
Zambia	3	Panama	6
Jamaica	3	Spain	6

Annex

Table 4. Estimated number of endemic amphibian species in the 50 most endemic-rich countries by this measure.

Brazil	294
Australia	169
Mexico	169
Madagascar	142
Colombia	141
Ecuador	136
China	131
United States	122
India	110
Indonesia	100
Papua New Guinea	100
Peru	86
Venezuela	76
Cameroon	65
Zaire	53
Philippines	44
Tanzania	40
Malaysia	39
Argentina	37
South Africa	36
Cuba	36
Japan	35
Costa Rica	34
Ethiopia	30
Viet Nam	26
Chile	25
Guatemala	25
Angola	23
Panama	22
Sri Lanka	19
Jamaica	18
Haiti	17
Dominican Republic	15
Puerto Rico	14
Bolivia	14
Thailand	13
Seychelles	11
Kenya	10
Guyana	10
Italy	10
Myanmar	9
Honduras	9
São Tomé and Príncipe	9
Nepal	7
Suriname	7
Taiwan	6
Iran	5
Liberia	4
Ghana	4
Gabon	4

Priorities for Conserving Global Species Richness and Endemism

This report was prepared by the World Conservation Monitoring Centre in June 1994 under contract to the Overseas Development Administration, UK. The task assigned to WCMC, with particular reference to the *Convention on Biological Diversity*, was: to discuss priorities for the conservation of global biological diversity, to assess what policies would be required, to suggest where the Convention and its financial mechanism should focus their efforts, and with what results in mind. The document is now made available in the present format by kind permission of the ODA.

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